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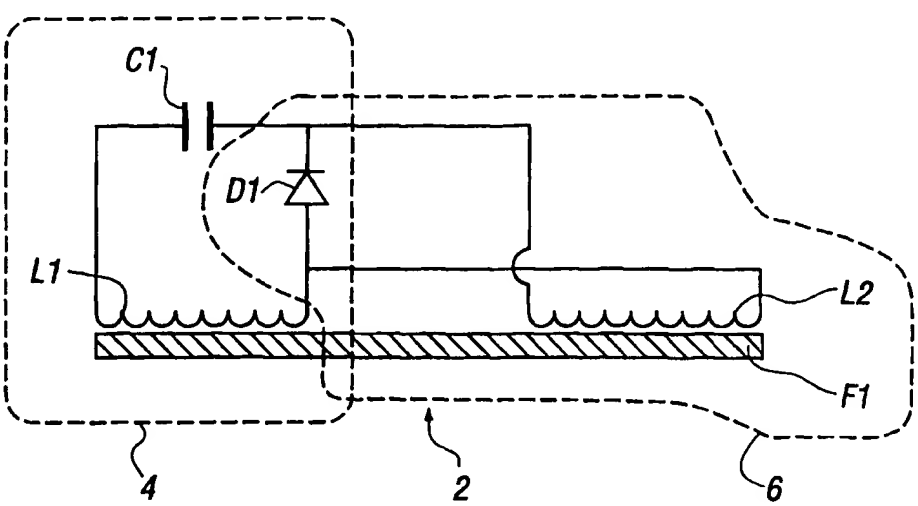
(54) Title: BATTERY-LESS TRANSPONDER CIRCUIT



(57) Abstract

A battery-less transponder circuit for use in an Electronic Article Surveillance tag is disclosed. The transponder is comprised of first and second resonant circuits which are electrically coupled across a common component and yet resonate at different frequencies. The first resonant circuit ideally comprises an inductor, a capacitor, and a diode, and the second resonant circuit consists of only an inductor which is mutually coupled to the inductor of the first resonant circuit but is connected across the diode of the first resonant circuit. This connection has the effect of giving rise to a second resonant circuit which is both electrically and magnetically coupled to the first resonant circuit. An extremely inexpensive yet effective transponder circuit results.

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Battery-Less Transponder Circuit

This invention relates to a battery-less transponder circuit for use in an Electronic Article Surveillance system (EAS system). The circuit is typically provided in a tag which is detected by the EAS system and which is attached to an article to prevent unauthorised removal thereof from the premises in which the system is installed.

EAS systems are usually installed in clothing, book, pharmacy, hi-fi, white good, and some music retail outlets to prevent unauthorised removal of articles therefrom. The systems typically comprise one or more transmitters and detectors in the form of pedestals located at the customer entry/exit points of a retail outlet. These pedestals transmit a signal to a tag, provided internally with a transponder circuit, the tag being attached to the article. The transponder circuit responds to a transmitted magnetic signal by re-radiating a second signal which is detected by the said pedestals thus triggering an alarm to indicate an attempt at unauthorised removal of articles. The tags may be permanently or releasably attached to the article. At the point of sale of the article, the tag is either removed from the article, or is deactivated if permanently attached thereto.

EAS tags and systems are designed around different operating parameters, and the primary systems currently in use are Split Frequency (SF), Radio Frequency (RF), Acousto-magnetic (AM), Microwave Frequency (MF), Electromagnetic (EM). This invention is primarily concerned with a transponder circuit which may be incorporated within a tag used in SF and EM systems in which the tag is releasably attached to an article such that it can be reused after removal therefrom.

In the SF and EM systems, an alternating magnetic field is transmitted between the pedestals and the tag is typically provided with a transponder circuit comprising, in its simplest form, a pair of LC resonant circuits which are electrically and/or magnetically coupled such that the second resonant circuit re-radiates a signal at a different frequency to that transmitted by the pedestals. This allows the pedestals to detect an active tag on an article as it passes therebetween.

An important consideration in the design of any EAS system pedestals and tags is that the "pick rate" of the system, i.e. the percentage of tags moving between the pedestals which activate the system is as high as possible, as tags which pass undetected between the pedestals allow the unauthorised removal of the article to which they are attached.

As tags may be attached to a large number of articles within the retail premises where the EAS system is installed, there is a requirement that the tags are

inexpensive, and therefore the inclusion of complex transponder circuitry or the provision of a battery powered transponder circuit are precluded. The fact that many currently available EAS systems have a pick rate which is substantially below 100% (~65-70% is common) is a result of the relative weakness of the signal which is re-radiated by the transponder circuit of the tag as it passes between the transmission/detection pedestals. Furthermore, the signal re-radiated by the transponder circuit must be of sufficient strength to induce a current in an inductance coils which forms the detection circuit of the pedestals. If this does not occur, then the tag escapes detection, and the article to which it is attached may be removed without authority.

There are a wide variety of transponder circuits employed within modern EAS tags, but in general there are two resonant circuits comprising at least one inductance in each circuit, and a reactance element such that the impedance of the overall circuit is minimised at a particular frequency. Moreover, the magnitudes of the inductive and reactive elements of each circuit are specifically chosen such that the one of the transponder resonant circuits resonates at a first frequency which is identical to the frequency of the magnetic signal transmitted by the pedestals. When the first circuit receives such a signal at the relevant frequency, the second circuit resonates at a second frequency, which is usually half that of the first frequency, by means of the magnetic and/or electric coupling that may exist in the transponder circuit as a whole.

Although not essential, the inductances of the first and second resonant circuits are generally disposed on a core of a ferromagnetic material to enhance the mutual coupling therebetween, and allow the self-inductance values of each inductance to be varied (and thus the transponder circuit as a whole to be "tuned") by displacing the inductance coil such that its core is only partially filled with the ferromagnetic core.

Where the inductance coils of the first and second resonant circuits are magnetically coupled in this manner, there is generally a mathematical restriction on the mutual coupling between these components. Circuits which are too effectively mutually coupled fail to re-radiate a signal at a second and different frequency from that transmitted by the pedestals.

Furthermore, it has be shown that certain resonant circuits become more sensitive and as a result more difficult to tune as the mutual coupling therebetween is increased. More specifically, the mutual coupling between the inductance coils of a resonant circuit affects the resonant frequency of each of said resonant circuits because the mutual inductance between the coils is reflected as an additional

impedance in each of the resonant circuits. Also, the extent to which the inductance coils are disposed on a ferromagnetic core linking the two coils can affect both the mutual inductance between the coils and the self-inductance value within a resonant circuit.

Thus, the inclusion of a ferromagnetic core aids the ability of the transponder circuit to concentrate the magnetic flux of the magnetic transmitted signal, but has a sensitising effect on the transponder circuit.

It will be appreciated by persons skilled in the art that by adjusting the position of the resonant circuits on the ferromagnetic core, the circuits can be tuned to provide a maximum response characteristic to magnetic radiation transmitted by the pedestal and received by the tag at a first frequency.

It is the object of this invention to provide a transponder circuit for an EAS tag which is intrinsically simple, inexpensive to manufacture and produce, and which mitigates the disadvantages of "tuning" described above which are more common with complex transponder circuits, or transponder circuits which incorporate variable reactance elements.

According to the invention there is provided a transponder circuit comprising first and second resonant circuits, said first resonant circuit comprising at least a first inductance, a reactive component and at least one other impedance component, said second resonant circuit comprising at least a second inductance mutually coupled to the first inductance and a reactive component, characterised in that the first and second resonant circuits are electrically coupled across a circuit component common to both resonant circuits which may be the said reactive component, and in that the resonant frequencies of the said electrically coupled circuits are different.

It is most preferable that the first and second resonant circuits are electrically coupled across the reactive component which is thus shared betwixt the first and second resonant circuits.

The transponder circuit is preferably battery-less.

It is preferable that the at least one other impedance component is a reactive component, and further preferably being a capacitor.

It is preferable that the component with reactance is a diode.

Preferably, the mutual coupling between the first and second inductances is enhanced by disposing said inductances on a common ferromagnetic core.

In its most preferred embodiment, the transponder of the invention is comprised of a first inductance, a capacitance and a diode, and the second resonant circuit comprises a second inductance mutually coupled to the first inductance and a diode, the said first and second resonant circuits being electrically coupled across and sharing said diode.

The simple circuit described above is inexpensive as the components comprised therein are freely available and are also inexpensive, and when the inductances are mutually coupled and disposed on a ferromagnetic core as disclosed, the tuning requirements of the transponder circuit are minimised, if not eradicated.

A specific embodiment of the invention is now described by way of example only with reference to the accompanying figure (Figure 1) which shows a schematic electrical circuit diagram for a transponder circuit according to the invention.

As shown in Figure 1, a transponder circuit 2 is provided with a first resonant circuit shown enclosed in the dotted lines at 4, and a second resonant circuit shown enclosed by the dotted lines at 6. It will be instantly seen from the schematic that a diode D1 is shared by both resonant circuits, and that both resonant circuits 4, 6 are electrically coupled across said diode.

Additionally, the first resonant circuit indicated at 4 comprises an inductance coil L1 which is provided around a core F1 of a ferromagnetic material, and also a capacitance C1. The combination of these inductive and reactive elements ensures that the circuit 4 resonates at a particular frequency. The second circuit 6 comprises only an inductance L2 in series with the common diode D1, and as the diode is essentially a reactive component, the second circuit will also have a frequency at which it resonates. The resonant frequency of the second circuit will be different from that of the first circuit, because the impedance of both circuits is different. Ideally, the magnitudes of the various inductive and reactive components should be chosen to ensure that the resonant frequency of the second circuit 6 is approximately half the resonant frequency of the first circuit.

It is to be appreciated that a large number of possible transponder circuit configurations is possible which still remaining within the scope of this application.

CLAIMS:

1. A transponder circuit comprising first and second resonant circuits, said first resonant circuit comprising at least a first inductance, a reactive component and at least one other impedance component, said second resonant circuit comprising at least a second inductance mutually coupled to the first inductance and a reactive component, characterised in that the first and second resonant circuits are electrically coupled across a circuit component common to both resonant circuits which may be the said reactive component, and in that the resonant frequencies of the said electrically coupled circuits are different.

2. A transponder circuit according to claim 1 characterised in that the first and second resonant circuits are electrically coupled across the reactive component which is shared between the first and second resonant circuits.

3. A transponder circuit according to any of the preceding claims characterised in that said transponder circuit is battery-less.

4. A transponder circuit according to any of the preceding claims characterised in that the at least one other impedance component is a reactive component

5. A transponder circuit according to claim 4 characterised in that the at least one other impedance component is a capacitor.

6. A transponder circuit according to any of the preceding claims characterised in that the component with reactance is a diode.

7. A transponder circuit according to any of the preceding claims characterised in that the mutual coupling between the first and second inductances is enhanced by disposing said inductances on a common ferromagnetic core.

8. A transponder circuit according to any of the preceding claims characterised in that the first resonant circuit is comprised of a first inductance, a capacitance and a diode, and in that the second resonant circuit is comprised of a second inductance mutually coupled to the first inductance and a diode, the said first and second resonant circuits being electrically coupled across and sharing said diode.

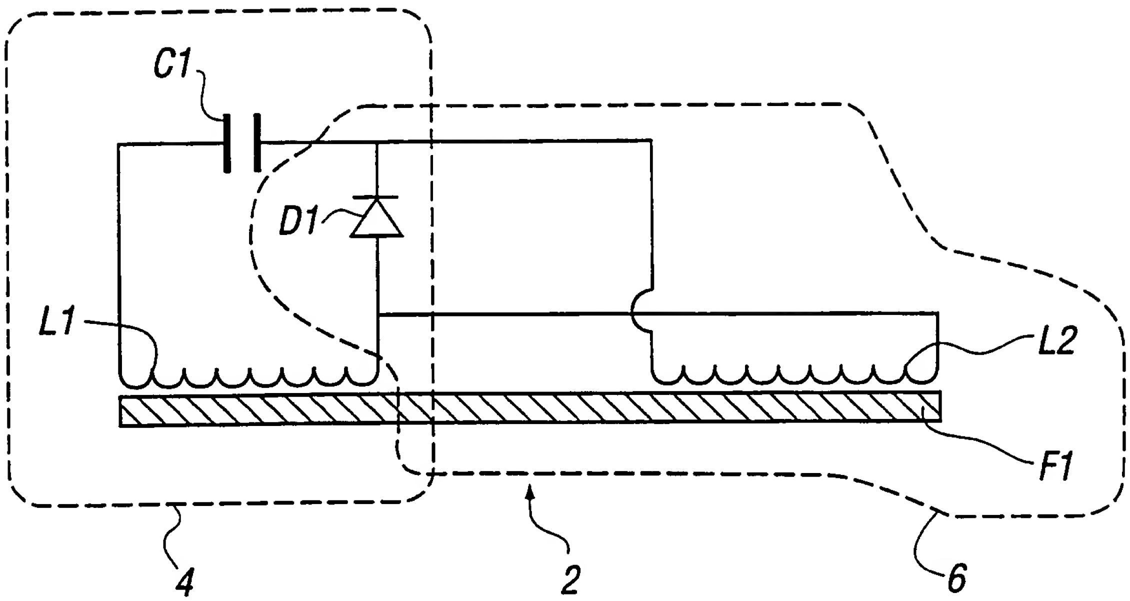

FIG. 1

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G08B13/24 G06K7/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G08B G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 517 179 A (CHARLOT LINCOLN H JR) 14 May 1996 (1996-05-14) column 1, line 66 -column 2, line 42 column 3, line 55 - line 61 claims 1,10 figures 1,3,7 ---	1-8
X	EP 0 561 559 A (SECURITY TAG SYSTEMS INC) 22 September 1993 (1993-09-22) page 3, line 55 -page 4, line 15 page 4, line 42 - line 51 figures 1,1A,2 figure 1 ---	1-7
A	US 4 572 976 A (FOCKENS TALLIENCO W H) 25 February 1986 (1986-02-25) --- -/--	1-8

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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19 October 1999	26/10/1999

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 299 557 A (NEDAP NV) 18 January 1989 (1989-01-18) -----	1-8

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